SAWYER

Hydrant Rental

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HYDRANT RENTAL

BY

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Donald Hubbard Sawyer

ENTITLED Hydrant Rental

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Municipal and Sanitary Engineering.

A N Talbot

HEAD OF DEPARTMENT OF Municipal & Sanitary Engineering.

Hydraut Rental

The proper charge for hydrant rental is of importance to both the private water company and the municipality paying it. Cities pay large sums for the fire protection element of water-works, but so far as the writer knows there has been little effort made to determine what charge for hydrant rental is just. The importance of the subject is realized by considering the great number of water-works plants in existence receiving remuneration from cities for fire protection.

When a water company applies for a franchise to supply a town with water, it seeks to install a large number of hydrants on the system and to receive in return for these as large a yearly revenue as possible. In few cases does the company itself know what a just

charge is, its only basis for such a charge being that made in similiar localities under similiar conditions. The ordinary town, on the other hand, is entirely helpless in the matter and only attempts to hold the charge down to that made in a few neighboring cities coming to their notice. In not a few cases the rental of hydrants is made such as to form a bonus for the water company to encourage the construction of the works. This is most frequently done where the city is small and the prospective receipts from other sources is not promising, or where the development of a supply or other unfavorable condition makes the installation unusually expensive. In cases of this nature the equitable charge is not sought but merely that which may prove satisfactory to both parties to the agreement. Many water-works officials assume that the domestic use of water should pay for operating expenses and that the revenue from

the rental of hydrants may be considered as profit. The reason for such an assumption is not evident.

In this thesis an effort is made to investigate the charge which may be called equitable and just between water-works company and city. While it is known that such charge must vary with the varying conditions of different cities, it is hoped that despite the personal equation which must enter into any design and estimate the results are close to the mean of the condition of the smaller inland cities of the middle west. The treatment will include, (1) The insurance rate, (2) Present hydrant rental rates, and (3) Excess of cost of fire protection and domestic service together over domestic service alone to be reduced to a per hydrant basis.

— The Insurance Rate —

It was hoped to obtain from insurance

companies data which would permit hydrant rental and fire protection to be balanced against increase of insurance rates for unprotected risks. It was thought possible that such data would allow the finding of the conditions and increased size of town where it would be economical to install a complete system or to change from a domestic to a fire system.

It is well known that fire insurance rates are very largely governed by the conditions attending the protection of buildings against fire. However, the mere fact that a city has a water plant and that hydrants are distributed over the built-up portions does not necessarily indicate that the insurance rates are lower than those in towns not so supplied. The rates established by insurance companies are generally arbitrary and what may be true in one city may be no basis for comparison in another. The insurance rate depends upon the

character and closeness of structures, the number and position of hydrants, availibility of water plant in case of fire, reserve supply of water, number of firemen constantly on duty and other conditions.

Data relating to this phase of the subject were difficult to obtain. Insurance men seem to have no accurate information concerning it. Besides, so many elements enter into it that it is too complex for adequate treatment. For these reasons the bearing of insurance rates upon hydrant rental will not be further considered. However, the following statement may be taken as true, considering its general character and that particular circumstances will control its use:- when the difference between the annual cost of insurance of a city not protected against fire and that of the same city with fire protection is less than the corresponding annual cost of a fire system over a domestic system, then it is not economical

to install a system providing fire protection. This takes no account of the fact that cities are rapidly growing, that water-works are designed for years in advance and that governing conditions are constantly changing.

— Present Hydrant Rental Rates —

As has been said no set rules fix hydrant rentals; and so, as might be expected, there is no evident relationship in the rates at present charged by water companies. A table has been compiled from data found in the thesis of R. P. Brower University of Illinois, '97 and in the American Water-Works Manual of 1897. The cities given are thought to be representative in population and conditions and similar to those used later in this work. Charges vary according to the franchise under which a company holds its rights. Thus a different charge is made for hydrants above a certain number.

— Table I. —

Hydrant Rental Rates in the Middle West.

City	Population	Hydrants per Mile of Main	Hydrant Rental per Year	City	Population	Hrd. per Mile of Main	Hydrant Rental per Year
Alpena, Mich.	14,000	5.9	$62.00	Marion, Ohio.	8,300	10.8	38.00
Ann Arbor, Mich.	9400	4.2	45.00	Mt. Jackson, Ind.	300	8.8	50.00
Circleville, Ohio.	6.500	10.0	35.00	Muscatine, Iowa.	12,000	10.1	75.00
Clinton, Iowa.	25,000	8.9	45.00	Noblesville, Ind.	3,000	10.0	33.00
Conneaut, Ohio.	3,200	6.4	37.50	Oconto, Wis.	5,700	15.4	65.00
Council Bluffs, Ia.	21,500	7.0	75.00	Pontiac, Ill.	2,800	12.0	42.00
Davenport, Iowa.	26,800	9.8	40.00	Quincy, Ill.	31,500	5.7	46,00
Eau Claire, Wis.	20,000	11.7	46.00	Rockford, Ill.	2,300	7.1	40.00
Fon du Lac, Wis.	14,000	10.8	58.00	Springfield, Mo.	21,800	4.0	55.00
Frankfort, Ind.	5,900	7.3	60.00	Springville, Iowa.	500	8.0	35.00
Franklin, Ind.	3,800	8.2	50.00	Streator, Ill	18,000	8.2	42.00
Haughville, Ind.	2,100	10.0	50.00	Superior, Wis.	26,000	15.0	40.00
Independence, Mo.	6,400	5.8	80.00	Terre Haute, Ind.	30,200	13.9	40.00
Indianapolis, Ind.	105,000	7.8	50.00	Topeka, Kan.	31,000		50.00
Janesville, Wis.	12,000	9.1	25.00	Warren, Ohio.	6,000	7.0	45.00
Ludington, Mich.	7,500	8.8	40.00	Xenia, Ohio.	7,300	7.7	37.50
				Mean		8.8	$47.88

A general idea of hydrant-rates may be obtained from the following table compiled from the "Manual of American Water-Works" for 1888.

— Table II. —

Hydrant Rentals in the United States in 1888.

Hydrant Rate	North Western	South Western	Pacific	Total for Western	Total for Eastern	Total in U.S.
$5			2	2	9	11
10			2	2	16	18
15					29	29
20			4	4	22	26
25		1	6	6	24	30
30	1	2	2	5	33	38
35	1	1		2	26	28
40	3	2	4	9	44	53
45	1	2	1	5	27	32
50	13	12	4	29	60	89
55	3			3	8	11
60	9	8	1	18	24	42
65	2	4	1	7		7
70	4	4		8		8
75	12	4		16	24	40
80	5	4	11	20		20
85	3	6	1	10		10
90		3		3	4	7
100	18	15	3	36	5	41
120			1	1		1
125		1		1		1
150		1		1		1
160				1		1
Mean Rate = $49.53						544

By comparing tables-I and II a close relationship is at once noticed in the final means.

while table II is of nearly ten years earlier date than table I it is not thought that this interferes in the comparison as the present basis of hydrant rentals takes no account of change of time. No explanation can be given for the similarity of results, except that each case has been decided by others like it and hence all are much the same.

—Excess of Cost of a Fire Protection System.—

The third part of the work – the actual difference in cost between a combined fire protection and domestic service and a domestic system alone of water-works – furnishes the only accurate foundation upon which to base the charge for hydrants. Comparison with existing rates, even after much effort has been spent in obtaining the same conditions, may give only crude and unsatisfactory results.

The purpose is to select cities representing average conditions and to design (1) a system of

water-works to supply domestic demands only, and (2) a system providing fire protection as well. By obtaining the difference in cost in these two cases the proper charge for the rental of hydrants will result.

The cities selected as examples are Tolono, Paxton, Danville and Springfield, all situated in the central part of Illinois. These are chosen as representing mean conditions in this portion of the country, as well as the range between the smallest size of town which may be expected to support a profitable private water plant and the largest cities where plants are likely to be controlled by private companies. In very few instances is it a paying investment for private parties to install a water-works in a town of less than 1000 people. On the other hand the large city can rarely afford to have its water supplied by a private company. The source

of supply of the cities considered is also representation, as the majority of the prairie cities obtain water either from driven wells or near by streams.

The principles upon which the designs are based are similiar. Maps of the cities used were obtained and, knowing the local conditions as to business and residential districts, source of supply and probable location of hydrants, a plan of the distribution system was made showing all valves, hydrants and specials. The systems as laid out are planned to be adequate for a period of twenty years. In order to obtain the population for which to provide, the census reports for the years 1890 and 1900 for the cities considered were made use of and from these the probable size of the city after twenty years or the period wished was calculated. When known the per capita rate of consumption was

used, and 225% of this employed to obtain the size of mains. When provision was made for fire protection the governing element was the number and size of streams required to be concentrated at any one point. The same total length of pipe line was used in both systems, as well as an equal number of valves and specials. The source of supply was always the same except that the number of driven wells varied in the two systems. In all cases it was desired to obtain the most economical installation and operation.

In the domestic systems 3 inch cast iron pipe is used for the minimum size. Smaller pipe than this could be used as far as capacity is concerned, but sizes less than this cost more per ton of metal and are cast in sections less than 12 feet which materially increases the expenses of laying. When possible such an arrange-

ment is made that pumping only during the day is necessary — an elevated reservoir supplying the night draught.

To determine the size of mains in the fire system reference was made to authorities on the subject to obtain the proper number of streams for cities of various populations. 4 inch pipe is used in some cases to connect dead ends of 6 inch pipe. Large amounts of this size can also be used to advantage in very small cities. Hydrants are not placed on sizes less than 6 inches.

That the results may be relatively the same a table of prices is used throughout the estimates. These are given in table III page 14. That part of the expense of laying pipe relating to excavating, back filling, handling of pipe and labor in making joints is obtained from Ariston's Tables for medium digging compiled from work in Providence R.I. The price given for hydrants

and valves includes placing them in the ground. These prices were checked up with those prevailing at the present time and found to agree very closely. An additional 10% [illegible] is added to the total cost to cover engineering and contingencies

— Table III —

Price Basis of Estimates

Material	Price	Material	Price
3 In. Valves - Each	$5.00	3 In. C.I. pipe in ground - ft.	$.26
4 " " "	7.50	4 " " " "	.32
6 " " "	12.50	6 " " " "	.51
8 " " "	19.00	8 " " " "	.72
10 " " "	25.50	10 " " " "	.98
12 " " "	31.00	12 " " " "	1.24
16 " " "	58.00	16 " " " "	1.88
20 " " "	100.00	20 " " " "	3.00
24 " " "	150.00	24 " " " "	4.09
30 " " "	250.00	30 " " " "	5.08
Hydrants - Each	25.00	Cast Iron Pipe - per ton	24.00
Valve Boxes - "	4.50	Specials per pound	2½¢
Jute - per pound	5¢	Lead - " "	4¾¢

The cost of operation in each system is found by estimating the fuel or power required, the supplies likely to be needed, the repairs necessary and the item of labor. These cannot be determined with certainty but are probably as near correct in one case as another. The cost of fuel necessarily fluctuates with the amount of water pumped and the varying price of the kind used. Repairs can only be guessed at as it is altogether impossible to foretell what break or alteration may occur or be needed. Here, as in the cost of the systems, an additional per cent is added for contingencies.

Under the heading "Sinking Fund" will be given the amount which, if placed annually at 5% compound interest, will provide a sum sufficient for the rebuilding of the pumping plant at the end of 20 years and of the distribution system in 50 years. Such a fund as this is not always set aside by officials but there is

no doubt but what in carefully operated plants it should be to allow for future rebuilding.

The comparisons will be based upon the sums of the three items given above, namely, first cost, operation and sinking fund. This sum will be reduced to a per hydrant rate and also treated with reference to the miles of mains and population.

The cities for which water-works estimates have been made will now be considered in order of size.

= Tolono =

General: There is at present a municipal water plant in Tolono and this is used as a basis for the estimates. As now operated water is pumped by means of steam deep well pumps from a 6- and an 8-inch well into an elevated wooden tank from which the city supply is drawn. Pumping is necessary for only three or four hours a day for the greater

part of the year, but this involves the building of a new fire every time the pumps are started, which is not economical in operation. The distribution system was not sufficient for a town of this size nor were there hydrants enough to amply protect the property against fire. These defects were remedied in the design used. The population of the town was 902 in 1890 and 845 in 1900, this showing a slight decrease. The system as laid out provides for a population of 1000.

Domestic System. – The distribution system is laid out to give a sufficient supply to all parts of the town, and to allow for the small growth mentioned above. A daily per capita consumption of 60 gallons is assumed and the mains are designed to carry 225% of this. The most economical pumping plant to install and operate was found to consist of gasoline engines working the deep well pumps, each

placed in a separate brick building. Water from the wells passes to a wooden elevated tank seated on a 40 foot masonry tower from which the city's supply is obtained. The tank is of such capacity that pumping during the day is only necessary.

Estimate
First Cost

13,250 feet of 3" pipe @ .26¢	$3,445.00	
1,210 " " 4" " @ .32¢	387.20	
		3,832.20
14 - 3" Valves @ $5.00	70.00	
3 - 4" " @ 7.50	22.50	
		92.50
1135 # of Specials @ 2 1/2¢		28.37
17 Valve Boxes @ 4.50		76.50
Total Cost of Distribution System		$4,029.57
40' Masonry tower } 20'×30' Wooden tank }		3,000.00
3 - 8" Wells - 150' deep		1,800.00
3 - Deep well pumps		1,800.00
3 - 8 HP Gasoline Engines		600.00
3 - 8'×10' Brick Pump Buildings		300.00
Piping and Valves		150.00
		$11,679.57
Engineering and Contingencies 10%		1,167.95
Total Cost of System		$12,847.52

Operation

2800 Gallons of Gasoline @ 12¢	$ 336.00
Attendant	350.00
Clerk	150.00
Repairs and Supplies	100.00
	936.00
Add 10%	93.60
Total Annual Operating Expense	$1,029.60

Sinking Fund

Distribution System	10.93
Pumping Plant	264.51
Total	$ 275.44

Fire and Domestic System:— The location, length of pipe and position of valves and specials is the same as in the domestic system. Hydrants are located about 700 feet apart so that the entire town is fully protected against fire. The mains are designed to carry the maximum domestic supply as well as four 200 gallon fire streams. Some four inch pipe is used to connect the ends of six inch mains in order to further circulation and prevent stagnant water. The source of supply

is the same as in the former service although the number of wells is of course increased. The elevated tank is placed higher than before in order to furnish adequate fire pressure. Its capacity is also increased so that it will hold the usual night's consumption and also one hour's fire demand. In this way the attendant is given plenty of time to start the engines and commence pumping water. It is thought that this system is the most economical that can be used in cities under these conditions. The tank is of such size that it is not practicable to make it of wood and hence steel is used.

Estimate

First Cost

6,650 feet of 4" pipe @ .32¢	$2,128.00	
7,300 " " 6" " @ .51¢	3,723.00	
510 " " 8" " @ .72¢	367.20	
		6,218.20
6 - 4" Valves @ 7.50	45.00	
9 - 6" " @ 12.50	112.50	

2 - 8" Valves @ 19.00	38.00
	195.00
2370# of Specials @ 2 1/2¢	59.25
17 Valve Boxes @ 4.50	76.50
21 Hydrants @ 25.00	525.00
Total Cost of Distribution System	$ 7,074.45
60' Masonry tower / 20'x50' Steel tower	7,000.00
6 - 8" Wells	3,600.00
6 - Deep Well Pumps	3,600.00
6 - Gasoline Engines	1,200.00
6 - 8'x10' Brick Pump Buildings	600.00
Piping and Valves	350.00
	23,424.45
Engineering and Contingencies 10%	2,342.44
Total Cost of System	25,766.89

Operation

3,500 Gallons of Gasoline @ 12¢	$ 420.00
Attendant	400.00
Clerk	150.00
Repairs and Supplies	150.00
	1,120.00
Add 10%	112.00
Total Annual Operating Expense	$ 1,232.00

Sinking Fund

Distribution System	33.20
Pumping Plant	500.73
Total	$ 533.93

= Paxton =

General:— The city of Paxton is quite similar to Tolono in location and source of supply. The population increased from 2,187 in 1890 to 3,036 in 1900 and assuming this growth to be constant it was calculated that the population twenty years hence would be about 6,000. A standpipe in the present system acts as a reservoir but further than this nothing is known concerning the plant.

Domestic System:— The distribution system is designed for an average consumption of 60 gallons per capita and a maximum of 225% of this. The economical pumping plant was found to comprise pumping from wells by means of deep well pumps operated by gasoline engines set in separate pump houses. Water from the wells passes directly to an elevated tank from which the city supply is drawn. This tank is of such capacity

as to supply the nights consumption without pumping. The tank is set 50 feet above the ground, high enough to supply all the fixtures in the city:

— Estimate —

First Cost

37,675 feet of 3" pipe @ .26¢			$ 9,795.50	
1,875 "	4" "	@ .32	600.50	
750 "	6" "	@ .51	382.50	
375 "	8" "	@ .72	270.00	
75 "	10" "	@ .98	73.50	
				$ 11,122.00
29 - 3" Valves @ 5.00			145.00	
3 - 4" "		@ 7.50	22.50	
2 - 6" "		@ 12.50	25.00	
2 - 8" "		@ 19.00	38.00	
1 - 10" "		@ 25.50	25.50	
				256.00
2163# of Specials @ 2 1/2 ¢				54.07
36 Valve Boxes @ 4.50				162.00
Total Cost of Distribution System				$ 11,594.07
Masonry tower 50' } Steel tank 20'X60' }				8,500.00
6 - 8" Wells				3,600.00
6 - Deep well pumps				3,600.00
6 - 10 H.P. Gasoline Engines				1,500.00
6 - 8'X10' Brick Pump Buildings				600.00

Piping and Valves	$400.00
	29,794.07
Engineering and Contingencies 10%	2,979.40
Total Cost of System	$32,773.47

Operation

12,000 Gallons of Gasoline @12¢	$1,440.00
Supplies	200.00
Attendant	400.00
Clerks	500.00
Repairs	200.00
	$2,740.00
Add 10%	274.00
Total Annual Operating Expense	3,014.00

Sinking Fund

Distribution System	54.48
Pumping Plant	635.37
Total	$689.85

Fire and Domestic System:- The distribution system is designed to carry the domestic supply as well as 6-300 gallon fire streams. The length of pipe line, and locations of pipe, valves and specials is the same as in the case of the domestic service. Hydrants are placed about 700 feet

apart. A material change is made in the pumping plant, necessitated by the fire element. In a city of this size it is not feasible to build an elevated reservoir to hold water to be used for fire purposes. Hence a surface reservoir is employed holding about one fourth of a days domestic and fire supply. This demands that an engineer be on duty at all times to raise the pressure when a fire occurs. Steam power is substituted for gasoline.

Estimate

First Cost

3,000 feet of 4" pipe	@ .32¢	$960.00	
18,450 " " 6" "	@ .51¢	9,409.50	
15,850 " " 8" "	@ .72¢	11,412.00	
3,000 " " 10" "	@ .98¢	2,940.00	
450 " " 12" "	@ 1.24¢	558.00	
			25,279.50
10 - 4" Valves	@ 7.50	75.00	
18 - 6" "	@ 12.50	225.00	
1 - 8" "	@ 19.00	19.00	
5 - 10" "	@ 25.50	127.50	
2 - 12" "	@ 31.00	62.00	
			508.50

57 Hydrants @ 25.00	$1,425.00
15,499# of Specials @ 2½¢	387.47
36 Valve Boxes @ 4.50	162.00
Total Cost of Distribution System	$27,762.47
Covered Reservoir - 24,000 Gal. Cap.	6,000.00
8-8" Wells	4,800.00
Pumping Station Building	5,000.00
1,750,000 Gal. Fire Pump	1,100.00
600,000 Gal. Pump	700.00
6- Deep Well pumps	3,600.00
200 H.P. Boilers @ 12.00	2,400.00
Piping Valves etc	2,000.00
	$53,362.47
Engineering and Contingencies 10%	5,336.24
Total Cost of System	$58,698.71

Operation

1,200 tons of coal @ $1.25	$1,500.00
Supplies	100.00
Engineers	1,000.00
Repairs	300.00
Clerk	500.00
	$3,400.00
Add 10%	340.00
Total Annual Operating Expense	$3,740.00

Sinking Fund

Distribution System	130.36
Pumping Plant	927.99
Total	$1,058.35

— Danville —

Aside from the great difference in population the city of Danville differs from the two previous cities in source of supply. The distribution system given in R. P. Brown's thesis is used as the basis for the distribution system here. This was designed in 1897 for a period of twenty years hence for a population of 83,000. As the city is situated on a river it is natural that it should draw its supply from it. An unusual feature of the existing plant is a 42" x 408' stand pipe which acts merely as a relief valve on the system.

Domestic System:— Nothing new presents itself in the case of the distribution system. As there is a large electrical plant in Danville furnishing power at reasonable rates it was decided to utilize this to operate the pumps. The two power pumps in duplicate are geared to a single motor. These pumps take their supply from the river and pump it directly into

the mains. By an automatic arrangement they may be made to respond to the differences in pressure and consequently only occasional attention will be needed to operate them. No reservoir is required as its function is fulfilled by a dam across the river.

Estimate

First Cost

89,005 feet of 3" pipe	@.26	$23,141.30	
8,725 " " 4" "	@.32	2,792.00	
3,040 " " 6" "	@.51	1,550.40	
7,030 " " 8" "	@.72	5,061.60	
1,520 " " 10" "	@.98	1,489.60	
6,100 " " 12" "	@1.24	7,564.00	
2,000 " " 14" "	@1.56	3,120.00	
			44,718.90
75 - 3" Valves	@5.00	375.00	
3 - 4" "	@7.50	22.50	
3 - 6" "	@12.50	37.50	
3 - 8" "	@19.00	76.00	
3 - 12" "	@31.00	93.00	
			604.00
12,286# of Specials	@2½ ¢		307.15
88 Valve Boxes	@ 4.50		396.00
Total Cost of distribution System			$46,026.05

Dam across river	$1,000.00
2-2,500,000 Gallon power pumps	4,000.00
Electric motor	1,360.00
Pump House	3,000.00
Total Cost of System	$55,386.05
Engineering and Contingencies 10%	5,538.60
Total Cost of System	$60,294.65

Operation

Electric power @ 6¢ per KW	$3,000.00
Attendant	350.00
Supplies	300.00
Repairs	600.00
Superintendent and Clerks	2,500.00
	6,750.00
Add 10%	675.00
Total Annual Operating Expense	$7,425.00

Sinking Fund

Distribution System	216.32
Pumping Plant	446.94
Total	$663.26

Fire and Domestic System: — The length of mains, their location and that of all the valves and specials is the same as in the domestic service. The number of hydrants in the existing system is too few and so an increase is made which places them about

700 feet apart. The mains are designed to supply ten fire streams besides the water for domestic consumption. In cities of this size it is essential that fire pressure be available at all times and where so much power is necessary it is generally economy to operate an independent plant. Hence steam installation is used and high duty pumps to supply the water. An interesting point to be noticed is that the cost of electric power is above the cost of coal, but that steam installation is more expensive than electric motors and that the labor item is much higher in the case of the steam plant.

Estimate

First Cost

2,980	feet of	4" pipe	@.32	$953.60
87,540	"	6"	" @.51	47,095.40
4,980	"	8"	" @.72	3,585.60
16,150	"	10"	" @.98	15,827.00
2,670	"	12"	" @1.24	3,310.80
8,100	"	16"	" @1.88	15,228.00
				$81,000.40

5 - 4" Valves @ $7^{\underline{50}}$	\$37.50	
63 - 6" " @ $12^{\underline{50}}$	787.50	
3 - 8" " @ $19^{\underline{00}}$	57.00	
12 - 10" " @ $25^{\underline{50}}$	306.00	
2 - 12" " @ $31^{\underline{00}}$	62.00	
3 - 16" " @ $58^{\underline{00}}$	174.00	
		\$1,424.00
160 Hydrants @ $25^{\underline{00}}$		4,000.00
55,600# of Specials @ 2½¢		1,390.00
88 Valve Boxes @ $4^{\underline{50}}$		396.00
Total Cost of Distribution System		\$88,210.40
Dam across river		1,000.00
2 - 4,000,000 Gal. High Duty Pumps		20,000.00
480 HP of Boilers @ $12^{\underline{00}}$		5,760.00
Pump House		4,500.00
		\$119,470.40
Engineering and Contingencies 10%		11,947.04
Total Cost of System		\$131,417.44

Operation

2,000 tons of coal @ $1^{\underline{25}}$	\$2,500.00
Supplies	300.00
Repairs	500.00
Superintendent	2,500.00
Engineers	1,800.00
Firemen	1,200.00
	8,800.00
Add 10%	880.00
Total Annual Operating Expense	\$9,680.00

Sinking Fund

Distribution System	$414.82
Pumping Plant	1,595.97
Total	$2,010.79

Springfield

This city is the largest size here considered for the reason that, as has been stated before, very few cities of this class are supplied by private companies. The basis of design for the distribution system was an old map of the city showing the locations of all mains and hydrants. This design was increased to fulfill the requirements of a city of 35,000 people. Springfield obtains its water from galleries near the Sangamon river some distance from the city. For a city of its size there are a very small number of hydrants.

Domestic System:- The mains carrying the water from the source of supply to the city are necessarily large in order to keep the loss of head

Small Steam is used at the pumping station as it furnishes the most economical power.

Estimate

First Cost

112,900	Feet of 3" pipe	@.26	$29,354.00		
31,300	" 4" "	@.32	10,016.00		
2,700	" 6" "	@.51	1,377.00		
1,900	" 8" "	@.72	1,368.00		
800	" 10" "	@.98	784.00		
800	" 12" "	@1.24	992.00		
6,800	" 20" "	@3.00	20,400.00		
21,120	" 24" "	@4.09	86,380.80		
				$150,671.80	

114 - 3" Valves	@ 5.00	570.00		
24 - 4" "	@ 7.50	180.00		
1 - 6" "	@ 12.50	12.50		
1 - 8" "	@ 19.00	19.00		
1 - 10" "	@ 25.50	25.50		
4 - 20" "	@ 100.00	400.00		
1 - 24" "	@ 150.00	150.00		
			1,357.00	

22,000# of Specials @ 2 1/2¢	550.00
145 Valve Boxes @ 4.50	652.50
Total Cost of distributing System	$153,231.30
2 - 3,000,000 Gallon High Duty Pumps	12,000.00
1320 H.P. of Boilers @ 12.00	15,840.00

Pump House Building	$6,000.00
Piping, Valves etc	4,000.00
Developing water supply	10,000.00
	$201,071.30
Engineering and Contingencies 15%	30,160.69
Total Cost of System	$231,231.99

Operation

4,500 tons of coal @ 1^{00}	$4,500.00
Supplies	500.00
Repairs	800.00
Superintendent	2,000.00
Engineers	2,000.00
Firemen	3,000.00
Clerks, Inspectors etc	4,000.00
	16,800.00
Add 10%	1,680.00
Total Annual Operating Expense	$18,480.00

Sinking Fund

Distribution System	720.18
Pumping Plant	2,240.00
Total	$2,960.18

Fire and Domestic System:— The length of mains, their location and that of all the valves and specials is the same as in the domestic system. Hydrants are placed about 700 feet apart — this being much closer

than on the existing system. The mains are designed to supply twelve 250 gallon fire streams besides the supply for domestic purposes. The only change in the pumping plant over the former system is the increased capacity.

Estimate

First Cost

2,800	feet of	4"	pipe	@.32	$896.00
102,000	"	" 6"	"	@.51	52,020.00
21,600	"	" 8"	"	@.72	15,552.00
15,000	"	" 10"	"	@.98	14,700.00
4,300	"	" 12"	"	@1.24	5,332.00
2,700	"	" 16"	"	@1.88	5,076.00
2,000	"	" 20"	"	@3.00	6,000.00
6,800	"	" 24"	"	@4.09	27,812.00
21,120	"	" 30"	"	@5.94	125,452.80
					$252,840.80

6-4"	Valves	@7.50	45.00
103-6"	"	@12.50	1,287.50
20-8"	"	@19.00	380.00
7-10"	"	@25.50	178.50
3-12"	"	@31.00	93.00
1-16"	"	@58.00	58.00
1-20"	"	@100.00	100.00
4-24"	"	@150.00	600.00

1-30" Valve @ 250.00	$250.00
255 Hydrants @ 25.00	6,375.00
93,400# of Specials @ 2 1/2¢	2,335.00
145 Valve Boxes @ 4.50	652.50
Total Cost of Distribution System	$265,190.30
3-3,000,000 Gallon high duty pumps	18,000.00
1800 H.P. of Boilers @ 12.50	22,500.00
Pump House	8,000.00
Piping Valves etc	5,000.00
Developing Water Supply	15,000.00
	333,750.30
Engineering and Contingencies 15%	50,063.[illegible]
Total Cost of System	$383,8[illegible]

Operation

6,000 tons of coal @ 1.00	$6,000.00
Supplies	550.00
Repairs	900.00
Superintendent	2,000.00
Engineers	2,000.00
Firemen	3,000.00
Clerks, inspectors etc	4,000.00
	18,450.00
Add 10%	1,845.00
	$20,295.00

Sinking Fund

Distribution System	1,246.59
Pumping Plant	3554.13
Total	$4,800.72

Summary

The results of the foregoing designs and estimates are shown in Tables IV and V

Table IV gives statistics relating to hydrants. The column headed "Hydrants per mile of mains" gives a mean of about 7.4. This corresponds very nearly with that in existing plants.

—Table IV—

Mains and Hydrants.

City	Population in 20 years	Miles of Mains	Number of Hydrants	Hydrants per 1000 of Pop.	Hydrants per Mile of Main
Tolono	1,000	2.74	21	21	7.7
Paxton	6,000	7.72	57	9.5	7.4
Danville	25,000	22.23	160	6.5	7.2
Springfield	35,000	33.77	255	7.3	7.3

Table V presents the final results of the calculations. Column 4 is the difference between 5 and 3 and includes all the amount added for engineering and contingencies. To obtain column 7

column 6 was considered as placed at 6% interest. Column 12 is the sum of 7, 9 and 11. The sinking fund in columns 10 and 11, as before explained, provides an annual sum which, if placed at 5% compound interest, will give means to rebuild the pumping plant in twenty years and the distribution system in fifty years.

7½ hydrants per mile and $50.00 per hydrant is nearly the same to the water company as 13 hydrants per mile and $30.00 per hydrant, and a charge of $40.00 per hydrant based upon one hydrant for each 400 feet of main is equivalent to a hydrant charge of $70.00 with 7½ hydrants to the mile. This element of the design must be kept in mind in making comparisons of hydrant rentals in different cities.

It must be remembered too that excessive cost of construction, or high operating expenses will increase the allowable hydrant charge.

Table V

Estimated Costs and Resulting Hydrant Rental

1	2	3	4	5	6	7	8	9	10	11	12	13	14
City	Kind of System	Cost of Distribution System	Cost of Pumping Plant	Total Cost	Initial Cost per Hydrant	Yearly Int. 6% one Hydrant	Additional Yearly Cost — Operation — Total	Additional Yearly Cost — Operation — Per Hyd.	Additional Yearly Cost — Sinking Fund — Total	Additional Yearly Cost — Sinking Fund — Per Hyd.	Total Yearly Cost per Hydrant	Yearly Cost — Per Mile of Main	Yearly Cost — Per 1000 People
Tolono	D.	4,029.57	8,817.95	12,847.52	615.21	36.91	1,029.60	9.64	275.44	12.31	58.86	451.09	1,236.06
	F. & D.	7,074.45	18,692.44	25,766.89			1,232.00		533.93				
Paxton	D.	11,594.07	21,179.40	32,773.47	454.83	27.28	3,014.00	12.74	689.85	6.47	46.49	343.26	441.65
	F. & D.	27,762.47	30,936.24	58,698.71			3,740.00		1,058.35				
Danville	D.	46,026.05	14,898.60	60,924.65	440.00	26.40	7,425.00	14.09	663.26	8.42	48.91	352.03	340.28
	F. & D.	88,210.40	43,207.04	131,417.54			9,680.00		2,010.79				
Springfield	D.	153,231.30	78,000.69	231,231.99	598.38	35.90	18,480.00	7.12	2,960.18	7.21	50.23	319.87	379.30
	F. & D.	265,195.30	118,623.29	383,818.59			20,295.00		4,800.72				

Conclusions

The results in the last three columns of table V show some interesting relationships.

In column 12 is found the final estimate of the reasonable hydrant charge under the conditions presented. It is to be expected that this charge must be higher in cities the size of Toledo.

With the same number of hydrants per mile the same relation will of course hold in column 13 as in column 12, and this similarity may be noted.

By an inspection of column 14 it is seen that the cost drops rapidly from Toledo to Dayton but that beyond this the cost is quite uniform and hence it may be assumed that for cities larger than [illegible],000 the hydrant cost per 1000 people would have an almost constant value.

The prices used in the estimate were checked up with those at present prevailing in the middle

cost. However, even if these varied considerably the comparison would not be materially influenced as the cost of the domestic system itself forms a very large part of the fire and domestic system.

A comparison of the mean hydrants rates found in tables I and II and those deduced in table V shows a remarkable similarity. It is seen that the mean rate charged in the prairie states is nearly the same as that given for the whole country and these two in turn agree almost exactly with the mean of column IV of table V. The similarity in the latter comparison cannot be accounted for. As before mentioned, hydrant rates are arbitrarily established and hence it may be said that this agreement is accidental. Finally, it is very fortunate for both the water-works company and the municipality that the ordinary hydrant rental charge accords so closely with that which has been found to be rational.

It is remarkable that rates charged for a long time, established on no seemingly rational basis should agree so closely with the estimated cost.